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Research Paper

Estimation Combining Ability, Heterosis and Some Genetic Parameters across Four Environments Using Full Diallel Cross Method

Mohammed A. H. Al-Falahy

Department of Field Crops, Collage of Agriculture, University of Duhok, Duhok, Kurdistan Region, Iraq

Corresponding author, e-mail: (dr.mohammed1953@yahoo.com)

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Abstract: *This study aimed to estimate heterosis and combining ability in respect of quantitative and qualitative traits by crossing five diverse maize inbred lines in full diallel mating design. Twenty F1 progenies along with their parents were planted in randomized complete block design with three replications in four environments in 2014. Combined analysis of variance showed highly significant difference (P. 0.01) between four environments, genotypes and interaction between them also the results was exhibited that both general (GCA) and specific (SCA) combining ability mean square were highly significant for number of days to 50% tasseling and silking, plant and ear height, leaf area, 300-kernel weight, number of rows ear-1 number of kernels row-1 and kernel yield plant-1, indicating the importance of both additive and non-additive genetic effects for these traits. However, high narrow-sense heritability, high degree of dominance also the results indicate that some the crosses main tested significant, positive heterosis for all traits while the traits, days to 50% tasseling and silking gave negative heterosis. The crosses (A105×DK), (A119×A132) and (DK×A132), with 146.49, 143.27 and 137.249 per plant were considered as a good combination for improving the trait. Most of the crosses with high mean of kernel yield had at least one parent (DK, A119 and A132) with significant GCA effect for these traits.*

Keywords: Diallel, Maize inbred, Sowing date, Plant densities, Faculty of agriculture.

Introduction

Maize (Zea mays L.) belongs to family Poaceae and is cultivated global as one of the most important cereal crops. In Iraq, it is the rank third position after wheat and barley. Corn production saw a sharp decline between the years of 2006 and 2011. Currently, Iraq requires approximately 300, metric tons of corn per year to satisfy the feed consumption of its growing poultry sector. In 2010, Iraq produced 150.000 metric tons of corn with average yield of 2 a metric ton per hectare, but imported the other 150.000 metric tons to meet the feed consumption requirement. The new hybrid seed corn varieties have the potential to raise productivity to a level of 6 metric ton per hectare. (www.inma-iraq.com).

Maize is widely spread and cultivated crop throughout the word due to its stability to grow in divers environment is unmatched by any the crop. (Chaudhary, 1993).

The mainly concerned to maize breeders, to increase grain yield, which have been utilizing the variable genetic resource which is need to search out the genetic material having potential of growth characters. The temperature and irrigation and soil fertility is more affected in maize growth and productivity. (Hefny, 2010). Muton et al., (2007) showed that temperature will increase from to year and this variable due to climate change. This change depends on the geographical location (IPCC, 2001). So that the planting dates have more effects on growth, yield and its components of maize. The various biometrical tools helps plant breeders in ascertaining the genetic formation.

The breeder can be obtained good information about genetic variation in a population from using diallels cross among selected parents. The diallel was the most commonly method for estimating the abilities and it has been often conduct in genetic research to estimate the inheritance of yield, yield components and more important characters with in asset of genotypes. (Bocanki et al., 2011). Also the objective of the diallel study is to determine genetic parameters like heterosis, heritability, gene action, phenotypic and genotypic correlation between yield and yield components to recognize and choose the best parents and crosses in breeding programs.

(Wattoo et al., 2009, Zare et al., 2011) performed complete diallel cross design in maize and the data show significant difference between the among genotypes for number of day to 50% tasseling and silking, plant height-1, ear height-1, number of ear plant-1, number of kernels rows-1, 100-kernel weight and grain yield plant-1. In the field maize different methods to determine the genetic material through inclusion in crosses by using researcher, according to a specific system (Dawood and Mohammed, 2011). The diallel technique is one of the conventional but powerful approach used in biometrical genetic to obtain sufficient information regarding the inheritance parents of quantitative characters. Griffing (1956) describe the procedure involves crossing asset of parental lines in all possible combination including their reciprocals.

Basbage et al., 2007 suggested that the combining ability analysis is more important for selection, so that a many researcher using different design to estimate the combining ability and gene effect for yield and yield components. Amiru Zzaman et al., 2013 showed that variance due to general combining ability (GCA) and specific combining ability (SCA) were high significant when studied the yield component and indicating both additive and non-additive type of gene action were controlling the traits while Hussain and Ali 2010) found that non-additive gene action were important for controlling for yield and other agronomic traits in maize. In the other study was conducted by (Kara, 2001, Ashih and Singh, 2003 Motawei, 2006, Aly and Hassan, 2011 and Aly 2013) found that the non-additive genetic effect played an important role in the inheritance of days to 50% silking, plant height, ear height, ear length, ear diameter, number of row ear-1 number of kernels row-1 and grain yield while the traits (number of ears 100 plant-1 and grain plant-1) was effected by the additive types of gene action.

Mohammed et al., 2014 and Abdel-Moneam et al., 2014 were estimated the combining ability and some genetic parameters for yield and yield components in maize using a half diallel mating design and full diallel cross, respectively. Combining analysis of variance showed significant mean square of general combining ability (GCA) and specific combining ability (SCA) for days to 50% silking, plant and ear height, ear length, number of rows ear-1 and kernels yield.

Heritability in narrow sense was highest for the most traits and the most crosses showed maximum positive heterosis over better parents and mid parents for the same traits. The present investigation aimed to (1) evaluate five inbred lines and their 25 F1 hybrids in full diallel cross for heterosis, combining ability and some genetic parameters across two sowing dates and two plant densities to identify the high (GCA) lines that could be used as parental lines in breeding program for specific traits and to identify promising hybrids with high (SCA) that could be used commercially. (2) study the possibility of predicting heterosis and combining ability in maize traits.

Materials and Methods:

This research was conducted at the field of faculty of Agriculture, Duhok University/Iraq Kurdistan Region. On March 15, 2013 five diverse maize inbred lines seeds from different source [DK. (P1.), Alo59 (P2), A119.(P3), A132(P4) and Pak(P5)] were sown to perform full diallel reciprocal crosses in all possible combination to obtain 20 hybrids. 2-3 seeds per hole were sown in two rows in block for each line. The row was 4cm long, distance between rows was 0.75m and spacing between plant was 25cm. seeding was done in two dates to achieve harmony in flowering of the inbred lines. At flowering stage three of four days before pollination, silke were cut to achieve uniform silk emergence. Then, the shoots were bagged with help of shoot bags with cramped safely between shoot and stalk to hold it in place. After that the tassel was covered with tassel bags when the silks became receptive they were pollinated by the pollen of the desire genotypes. At least five silks were manually pollinated in order to obtain sufficient seed of hybrid for sowing F1 crop on two sowing dates (spring and autumn, 2014) with two experiments separately.

During the spring and autumn season, 2014 all the F1 hybrids along with their parents were sown in randomized complete block design with three replications. Each entry was raised in one row with a row length 3m. The spacing between the rows was 0.75m and 0.20-0.30m between the plants. Data of the parents, the hybrids (each alone) and all genotypes (parents and hybrids) for all studied traits, were subjected to analysis of variance according to the experimental design used, and comparisons between means were done according to Duncans Multiple Range. Test method (Gomez and Gomez, 1983). Combining ability analysis was carried out using Griffings (1956) method (1) model (11) given in the biometrical method in quantitative genetic analysis by Singh and Chudary (1985).

The components of variance additive, dominance, total genetic and environmental were estimated and done broad and narrow sense heritability were determined. Heterosis as departure of F1 and reciprocal F1's from mid parents was estimated.

Results and Discussion

The analysis of variance for ordinary analysis and combining ability in four environments and combined data over four environments for studied traits is presented in table 1. Highly significant differences ($P<0.01$) between four environments, genotypes and environments and genotypes environments interaction were found for all studied traits, this indicates that variability exists among these populations may be increase the chance of good new recombination that can be isolated in the succeeding generations, and also the results in table 1 showed that the both general (GCA) and specific (SCA) combining ability mean square were highly significant for all studied traits. These results indicated that both additive and non-additive type of gene effects were involved in the inheritance of these traits. On the other hand, reciprocal mean squares were highly significant for all traits, except for PH under four environments. The results indicating that the maternal effect played an important role in the expression. These results are in line with the results of Secansk et al., 2005, Kim and Ayala, 1996 and Kang et al., 1995.

The interaction between GCA, SCA and reciprocals with four environments table 1 were significant or highly significant for the most studied traits. The magnitude of the interaction was lowest for GCA × environment than SCA × environments, for the most studied traits. This indicates that non-additive genetic variance was influenced by environments.

The non-additive effect component interacted more with the environments than the additive. This conclusion is in agreement with the findings by Motawei (2005) and Singh and Roy, (2007).

Table 1: Combined analysis, over two planting date and two plant densities for studied traits based on Griffing method 2

S.O.V.	D.F	Mean square								
		NDT	NDS	PH	EH	L.A	K.W	N.R	N.K.R	KYP
Environments (E)	3	** 62.26	** 675.42	** 38361.30	** 2761.58	** 71537.71	** 967.73	** 12.70	** 369.69	** 4337.47
(REP) E	8	2.22	3.06	742.51	183.69	1091.67	24.43	0.48	9.14	146.19
Genotypes G	24	** 41.12	** 33.51	** 5443.93	** 1027.46	** 58259.50	** 628.82	** 10.40	** 150.02	** 9041.31
E×G	72	** 7.25	** 8.84	** 599.36	** 247.15	** 19895.78	** 62.26	** 2.33	** 21.77	** 582.08
GCA	4	** 97.44	** 70.67	** 1255.24	** 918.95	** 20242.37	** 555.48	** 6.24	** 91.19	** 4249.82
REC.	10	** 27.40	** 25.21	458.28	** 399.90	** 16082.38	** 594.36	** 13.16	** 90.80	** 9638.16
GCA×E	4	2.48	4.95	592.98	** 434.61	** 35782.79	* 41.36	** 2.88	** 24.82	** 235.83
SCA×E	10	** 4.40	** 4.22	141.05	** 279.21	** 34734.16	** 60.22	** 4.55	** 23.00	** 924.35
SCA	10	** 32.30	** 26.95	** 1210.85	** 1698.42	** 115643.48	** 692.61	** 9.30	** 232.78	** 10361.05
REC×E	10	* 3.26	3.45	92.15	130.40	** 63472.66	** 56.64	** 4.23	** 27.89	** 650.07
Error	192	1.34	1.74	267.31	87.38	781.75	13.58	0.33	4.80	116.55

*and **, significant at 5% and 1% levels respectively

NDT. Days to 75% tasseling, NDS. Days to 75% silking, PH: plant height, EH: Ear height, L.A: leaf area cm^2, KW: 300 kernel weight, N.R: Number of rows per year, N.K.R: Number of kernels per row, KYP. KY. Kernel yield.

The combined data of mean performance across the four environments for grain yield and other agronomic traits of the five inbred lines and 20 F_1 crosses were presented in table 2. For the NDT, parent 3 took the maximum NDT of 79.25 days, while the parent 4 with 70.66 days found to be earliest. The differences among parental values affected significantly in their diallels and reciprocal crosses value. Regarding the hybrids values, the cross $P_4 \times P_5$ was found to be the latest, in which spent maximum NDT of 78.83 days. The hybrid $P_1 \times P_4$ required minimum NDT of 75.50 days. Concerning the reciprocal crosses, the cross $P_5 \times P_2$ took maximum NDT with 76.75 days, while the reciprocal cross $P_2 \times P_1$ with 74.66 day showed the lowest NDT. The results in table 2 indicate that inbred P_4 was the earliest in NDS while inbred P_3 could be considered the latest (82.33 days). The lowest value in these characters (77.33 days) was found in the hybrid $P_1 \times P_4$ while the hybrid ($P_4 \times P_5$) was the most delayed genotypes in NDS. Regarding the reciprocal crosses, the differences between crosses were not highly significant. The data in table (2) indicate that P_2 were shorter than others in PH (133.62 cm) and the P_5 was tallest one (163.14 cm). The hybrid $P_3 \times P_4$ was the tallest hybrid (208.33 cm), whereas the hybrid $P_4 \times P_5$ was the shortest in PH (182.4 cm). Concerning the reciprocal crosses the differences between PH for crosses.

Table 2: Means of full diallel crosses of five maize lines across four environments for the studied traits

genotypes	NDT	NDS	PH cm	EH cm	L.A cm^2	K.W g	N.R.E	N.K.E	KYP g
P_1	77.66 BC	79.33 BCD	138.27 H	69.83 J	516.47 H	46.74 KL	15.51 GHIJ	33.08 H	77.88 KL
P_2	78.58 AB	80.00 A13	133.62 H	71.16 IJ	450.51 I	44.71 ML	14.75 KLM	29.34 I	82.39 IJK
P_3	79.25 A	82.33 A	145.97 GH	72.25 IJ	503.08 H	43.43 M	14.60 LM	30.75 I	59.64 M
P_4	70.66 K	73.33 K	156.38 FG	81.16 GH	610.96 F	59.81 C	15.45 GHIJK	33.68 H	92.59 GH
P_5	77.50 CDE	79.25 BCD	163.14 F	81.16 GH	661.73 CD	55.38 DE	15.19 IJKL	35.78 FG	91.43 GHI
P_1×P_2	76.83 CDEF	78.41 CDEF	194.33 ABCDE	84.75 EFGH	682.38 BC	44.55 ML	17.90 AB	38.55 CDE	90.21 GHIJ
P_1×P_3	77.25 CDE	79.16 BCD	189.58 CDE	94.66 BCD	716.23 A	51.81 FGHI	18.10 A	37.40 DEF	112.24 EF
P_1×P_4	75.50 GHI	77.33 FGHI	187.91 CDE	93.58 BCDE	615.08 EF	58.20 CD	17.26 BC	40.59 B	137.29 ABC
P_1×P_5	77.41 CDE	79.00 BCD	199.75 ABC	95.75 BCD	518.53 H	42.72 M	15.65 FGHI	33.10 H	70.20 L
P_2×P_3	77.58 BCD	79.66 BC	195.08 ABCDE	92.58 BCDEF	693.60 AB	47.94 JK	16.09 EFGH	33.84 H	78.05 KL
P_2×P_4	77.08 CDE	79.33 CDE	194.00 ABCDE	89.91 CDEFG	561.30 G	49.18 IJK	15.97 EFGH	35.95 FG	80.85 JK
P_2×P_5	77.00 CDE	79.08 BCD	203.41 ABC	104.75 A	610.89 F	54.07 EFG	16.17 DEFG	39.21 BCD	111.90 EF
P_3×P_4	76.41 EFG	79.08 BCD	208.33 A	87.50 DEFG	613.25 F	67.38 A	15.36 HIJK	38.58 CDE	143.27 AB
P_3×P_5	77.66 BC	79.75 BC	206.25 AB	99.50 AB	639.10 DE	51.16 GHIJ	16.84 CD	40.79 B	123.70 D
P_4×P_5	78.83 A	81.83 A	182.91 DE	99.16 AB	662.65 CD	38.53 N	16.37 DEF	34.96 GH	50.29 N
P_2×P_1	74.66 I	77.33 IJ	201.08 ABC	89.75 CDEFG	615.83 EF	60.49 C	15.83 EFGHI	43.09 A	146.49 A
P_3×P_1	75.58 GHI	78.33 FGHI	182.41 E	82.91 GH	689.92 B	55.20 DE	16.80 CD	38.56 CDE	124.38 D
P_4×P_1	73.50 J	75.83 J	203.06 ABC	98.08 ABC	598.98 F	58.37 CD	14.84 JKLM	40.75 B	138.67 ABC
*P_5×P_1	74.75 I	76.66 HIJ	194.16 ABCDE	92.58 BCDEF	520.97 H	58.73 C	17.44 BC	39.25 BCD	133.16 C
P_3×P_2	76.50 DEFG	78.16 DEFG	189.25 CDE	84.16 FGH	661.44 CD	49.80 HIJK	16.44 DE	36.45 FG	85.96 HIJK
P_4×P2	75.91 FGH	77.58 EFGH	190.66 BCDE	78.41 HI	617.88 EF	52.84 EFGH	15.40 HIJK	34.99 GH	110.44 F
P_5×P2	76.75 CDEF	78.25 DEFG	195.25 ABCDE	97.32 ABC	620.38 EF	60.04 C	15.86 EFGHI	37.18 EF	98.34 G
P_4×P_3	74.91 HI	77.05 GHI	198.41 ABCD	87.03 EDFGH	550.88 G	64.21 B	14.25 M	40.30 BC	120.87 DE
P_5×P_3	75.16 HI	77.33 FGHI	201.75 ABC	94.41 BCD	696.44 AB	54.68 EF	16.08 EFGH	36.75 EF	117.79 DEF
P_5×P_4	74.75 I	77.16 GHI	196.25 ABCDE	85.41 EFGH	563.08 G	58.37 CD	16.51 DE	42.74 A	134.69 BC

Mean in each column followed by the same letter are not different at 5% probability using DMRT. Ranged from 182.41 to 203 cm in over four environments for the EH the P4 and P5 scored high EH

(81.16 cm). The hybrid P2×P5 showed the largest EH (104.75 cm) while the reciprocal cross scored the lowest EH (78.41 cm). For the L.A the larges flag. L.A was found in P2 (661.73 cm2), whereas the lowest L.A was that of P5 (450.51 cm2). The hybrid P1×P3 give the largest L.A (716.23 cm2) while the lowest one was observed in hybrid P1×P5 (518.53 cm2). 300 K-W, for parents range from 43.43 to 59.81g in parents P3 and P4 respectively. The differences among cross for 300 K.W. the highest mean was observed in hybrid P3×P4 (67.38g), while the hybrid P1×P5 gave the lowest grain weight (42.72g). Rows number of genotypes ranged from 14.25 to 18.10 over the four environments and recorded by P4×P3 and P1×P3 respectively. NKR parents ranged from 29.34 to 35.78 the highest value was recorded by P5 mean, while the lowest value was obtained by P2. For KYP the highest mean KYP was observed in P4 (92.59g), while the lowest KYP was recorded by P3 (59.64g). The highest KYP was obtained from cross P2×P1 (146.49g) and P3×P4 (143.27), respectively. Hence, it could be conclude that these crosses may be useful for improving maize grain yield program.

The mean of general combining ability effects of parents for all the traits across the environments is presented in table 3. Due to importance of early maturity and lowers value of NDT, and NDS which had significant negative GCA effects were considered as good combiner for this traits. Due to lower PH makes more tolerant to loading, therefore the parents, P, and P2 were suitable parent for this trait. The lowest mean of of EH also were observed for all parents, except for P5 and the value range between -1.92 to 0.17, respectively. Concerning for the L.A the variance of GCA effect maximum value exhibited by P3 with 19.04 followed by P5 with 7.88. P4 had significant positive GCA effects for KW with 3.54.

Data in the same table signify positive and negative value due to GCA for NKR. Maximum negative effect value was -0.19 produced by P2 and P4, while the positive effects value was 0.37 recorded by P1. The parent P1, P4, P5 had significant positive effect for NKR with 0.72, 0.60 and 0.52 respectively, while the another parents gave negative effects for this traits. Regarding the general combining ability effect due to parents, most parents showed negative GCA effect value, maximum negative GCA effect value was exhibited by P2 with -7.80 while the P1 and P4 gave the maximum positive value with 6.33 and 5.54. (Espinosa et al., 1998; Sierra et al., 2000) reported significant GCA effects for grain yield and yield components in a diallel crosses of maize inbred lines.

Table 3: General combining affects maize lines for kernel yield and related traits across four environment using Griffings method 2

Traits / Lines	NDT	NDS	PH cm	EH cm	L.A Cm^2	K.W (g)	N.R.E	N.K.R	KYP g
P_1	* -0.23	** -0.34	* -3.16	-1.14	** -8.58	* -0.78	** 0.37	** 0.72	** 6.33
P_2	** 0.63	** 0.40	* -3.01	* -1.92	** -11.19	**-2.30	** -0.19	** -1.23	** -7.80
P_3	** 0.64	** 0.69	N.S 0.25	N.S -1.58	** 19.04	N.S -0.23	N.S -0.02	** -0.60	N.S -1.95
P_4	** -1.48	** -1.19	N.S 1.37	-0.17	** -7.16	** 3.54	** -0.19	** 0.60	** 5.64
P_5	** 0.43	** 0.43	** 4.55	** 4.80	** 7.88	N.S -0.23	N.S 0.03	** 0.52	N.S -2.21

Ns, * and **: Non-significant, significant at 5% and 1%, levels, respectively.

NDT. Days to 75% tasseling, NDS. Days to 75% silking, PH. Plant height, EH: Ear height, L.A: leaf area, K.W: 300 kernel weight, NRE. Number of row per ear, N.K.R: Number of kernels per rows, KYP: Kernel yield.

The results of SCA of crosses across the four environments for different traits are presented in table 4. For NDT twelves crosses were exhibited significant negative SCA effect. This could be an indication that additive genetic effects were more important, while only two crosses showed the significant negative SCA effects for NDS. The parents can, therefore be used inbreeding for early maturity out of twenty crosses, eight crosses had significant positive SCA effects for PH. Regarding the SCA effect due to the diallel crosses for EH, maximum positive value was produced by the cross P2×P5 with 9.52 followed by cross P1×P4 with 8.82, while maximum negative SCA effect value exhibited by the cross P2×P1 with -2.50 nine out of the twenty crosses showed desirable significant specific combining ability effect under four environments for L.A. and four crosses produced significant negative SCA effects and the value range between -87.22 to 28.29 by crosses P1×P5 and P4×P2. The data in the same table reveal the estimation of SCA effects for 300 – K.W.

The maximum positive SCA effect value was recorded by the cross P3×P4 with value 9.34, while the maximum negative effect was -9.91 exhibited by the diallel cross P5×P4.

Values estimated SCA effects of hybrid for yield components characters are presented in table 4 from this table, we can see that the SCA effect for NRE (1.35) was the highest positive value exhibited by diallel cross P4×P1, whereas maximum Negative value was -1.10 for the combination (P5×P1).

For the NKR, the diallel cross (P1×P2) showed positive SCA value of 4.30, while the highest negative value for this trait was -3.88 was noticed for (P5×P4).For KYP, the same table points out the highest positive SCA observed in diallel cross (P3×P4) with 23.87, whereas the maximum negative value was -48.20 noticed in the cross (P5×P4) table 4.

Table 4: Specific combining effects of maize crosses for kernel yield and related traits across four environments using Griffings method 2

Crosses	NDT	NDS	PH cm	EH cm	L.A cm^2	K.W g	N.R.E	N.K.R	KYP
$P_1 \times P_2$	** 0.97	** -0.90	** 17.84	1.99	** 61.21	** 2.46	0.14	*** 4.30	** 15.31
$P_1 \times P_3$	-0.31	-0.32	2.86	3.20	** 84.94	1.37	** 1.03	0.84	** 9.42
$P_1 \times P_4$	-1.10	-0.10	** 11.20	** 8.82	* 15.10	** 2.39	-0.19	** 2.32	** 21.49
$P_1 \times P_5$	-0.42	-0.47	** 9.52	2.18	** -87.22	-1.40	0.15	** -2.09	** -6.94
$P_2 \times P_3$	* -0.53	-0.39*	* 8.87	3.55	** 62.00	* -1.73	0.11	-0.04	** -12.74
$P_2 \times P_4$	** 1.03	0.69	* 7.92	-2.06	0.27	** -3.35	** 0.41	-0.91	** -6.70
$P_2 \times P_5$	-0.50	-0.37	** 11.74	** 9.83	11.27	** 6.45	-0.07	** 1.87	** 10.63
$P_3 \times P_4$	0.18	0.36	** 15.69	0.72	** -37.47	** 9.35	** -0.76	** 2.42	** 23.87
$P_3 \times P_5$	** -0.97	** -0.87	** 13.14	** 5.41	** 33.18	0.24	* 0.28	** 1.82	** 20.40
$P_4 \times P_5$	** 1.57	** 1.54	-2.39	-0.66	4.47	** -7.99	** 0.58	0.70	** -15.44
$P_2 \times P_1$	** 1.08	** 1.04	-3.37	-2.50	** 33.27	** -7.99	** 0.83	** -2.27	** -28.14
$P_3 \times P_1$	** 0.83	** 0.91	3.58	* 5.87	13.15	-1.69	** 0.83	-0.57	** -6.06
$P_4 \times P_1$	** 1.00	* 0.75	-7.54	-2.25	8.05	-0.08	** 1.35	-0.07	-0.69
$P_5 \times P_1$	** 1.33	** 1.16	2.79	1.58	-1.22	** -8.00	** -1.10	** -3.07	** -31.48
$P_3 \times P_2$	0.54	* 0.75	2.91	4.20	* 16.07	-0.92	0.25	* -1.30	-3.95
$P_4 \times$P2	0.58	0.54	1.66	*	**	*	0.30	0.40	**

				5.75	-28.29	-1.83			-14.79
P_5×P2	0.12	0.41	4.06	3.70	-4.74	** -2.98	0.07	1.01	* 6.78
P_4×P_3	* 0.75	** 1.00	4.95	0.20	** 31.18	1.58	** 0.73	-0.86	** 11.20
P_5×P_3	** 1.25	** 1.12	2.25	2.54	** -28.67	* -1.76	** 0.55	** 2.02	2.95
P_5×P_4	** 2.00	** 1.83	-6.66	** 6.87	** 49.78	** -9.91	0.24	** -3.88	** -42.20

Ns, * and **: Non-significant, significant at 5% and 1%, levels, respectively.

NDT. Days to 75% tasseling, NDS. Days to 75% silking, PH. Plant height, EH: Ear height, L.A: leaf area, K.W: 300 kernel weight, NRE. Number of row per ear, N.K.R: Number of kernels per rows, KYP: Kernel yield.

Results given in Table 5 indicated that some the crosses manifested significant and highly significant, positive and negative hetrosis over mid-parent. For NDT (P2×P1, P3×P2 and P5×P3) showed maximum negative heterosis with value (-3.458, -2.875 and 3.208), respectively and the same crosses exhibited the negative heterosis for NDS. For PH all hybrids combination did manifest vigor, the hetrosis value ranged from a minimum of 23.15% relative to mid parents and maximum value was 65.13% recorded by crosses P4×P5 and P2×P1. For ear height almost all hybrid combination (diallel and reciprocal) crosses exhibited positive heterosis, the maximum positive heterosis was manifested by the hybrid combination (P1×P3) with value 23.62%, while the minimum value recorded by hybrid (P5×P4) with value 4.25.

Concerning the estimation of heterosis value for L.A. diallel cross P2×P3 had the highest positive value 216.80 heterosis values due to reciprocal crosses varied between -73.26 and 184.64 for crosses P5×P4, and P3×P2, respectively.

Data in table 5 clear that the highest significant and positive heterosis over mid-parents for 300 K.W was recorded by P3×P4 (15.75%) followed by P2×P4 14.77%. similar results were established by Katta et al., (2007) and Alam et al., (2008)_. In table 5 regarding to N.R.E, the highest significant heterosis and positive was recorded for 3 crosses (P2×P3, P3×P5, and P3×P2) had highly positively significant with values, 1.02%, 0.74% and 1.037% respectively. For N.K.R 18 crosses had highly significant and positive over mid-parent. These results are in accordance with Katta et al., 2007 and Alam et al., 2008. In the same table demonstrated that 14 hybrid combinations expressed significant heterosis in desirable direction for KYP compared to mid parent. The best performance for KYP was recorded for the hybrid combination P3×P4 and P2×P1. Significant negative heterosis was noticed for P1×P5, P2×P4, and P4×P5. This results was in agreement with those reported by [(E1-Ghonemy and Ibrahim 2010; Sultan et al., 2010 and Amanullah et al., 2011]. Table 6 presents estimates genetic parameters for the studied characters. This table showed that the variance of SCA was higher than variance of GCA and Vs for all studied traits, this indicate that the non-additive gene action more important in the inheritance of all studied traits. For vg/vc, the ratio a value was lower than one indicates dominant genetic effect controlling the study traits. The dominance variance was more than additive variance for all traits except NDT, this indicate that these traits were under control of the dominance gene effect. These results were in agreement with reports of other researchers.

Table 5: Estimates of heterosis effects of twenty single crosses maize across four environments for studied traits

Crosses	NDT	NDS	PH cm	EH cm	L.A Cm^2	K.W (g)	N.R.E	N.K.E	KYP (g)
P_1×P_2	-1.29	-1.250	** 58.382	* 14.250	** 198.887	-1.72	-0.070	** 7.338	10.066
P_1×P_3	-1.208	-0.916	**	**	**	**	0.208	**	**

			47.458	23.625	206.454	6.727		5.488	43.480
$P_1\times P_4$	1.333	1.000	** 40.587	** 18.083	** 51.372	* 4.924	* -0.74	** 7.209	** 52.047
$P_1\times P_5$	-0.166	-0.291	** 49.041	** 20.250	** 70.570	** -8.34	** -1.504	-1.324	* -14.451
$P_2\times P_3$	-1.333	-0.750	** 55.283	** 20.875	** 216.808	3.867	** 1.020	** 3.791	7.030
$P_2\times P_4$	** 2.458	* 2.000	** 48.995	* 13.75	* 30.567	-3.080	* 0.716	** 4.445	-6.647
$P_2\times P_5$	-1.041	-0.541	** 55.033	** 28.583	** 54.775	4.029	0.341	** 6.654	** 24.990
$P_3\times P_4$	1.458	* 2.00	** 57.154	10.791	** 26.234	** 15.758	0.520	** 6.362	** 67.156
$P_3\times P_5$	-0.708	-0.458	** 51.691	** 22.791	** 56.700	1.750	* 0.745	** 7.520	** 48.167
$P_4\times P_5$	** 4.750	** 4.541	* 231.154	** 18.00	26.304	** -19.066	0.533	0.233	** -41.717
$P_2\times P_4$	** -3.458	** -3.333	** 65.133	** 19.250	** 132.345	** 14.771	** -1.470	** 11.880	** 66.348
.$P_3\times P_1$	** -2.875	** -2.750	** 40.291	* 11.875	** 180.145	** 10.111	* -0.808	** 6.646	** 55.614
$P_4\times P_1$	-0.666	-0.500	** 55.670	** 22.583	* 35.263	* 5.092	** -2.404	** 7.367	** 53.433
$P_5\times P_1$	** -2.833	** -2.625	** 43.458	** 17.083	** -68.129	** 7.675	* -0.720	** 4.817	** 48.508
$P_3\times P_2$	** -2.416	** -2.250	** 49.450	* 12.458	** 184.648	* 5.726	** 1.037	** 6.400	** 14.941
$P_4\times P_2$	1.291	0.916	* 45.663	2.25	** 87.151	0.580	-0.241	* 3.479	** 22.945
$P_5\times P_2$	-1.291	-1.375	** 46.866	** 21.166	** 64.258	** 9.999	0.310	** 4.620	11.425
$P_4\times P_3$	-0.041	0.000	** 47.237	10.375	-6.136	** 12.590	* -0.762	** 8.087	** 44.756
$P_5\times P_3$	** -3.208	** -2.708	** 47.191	** 17.708	** 114.041	** 5.277	0.445	* 3.479	** 42.250
$P_5\times P_4$	0.75	0.875	** 36.487	4.25	** -73.265	0.769	0.258	** 8.008	** 42.683

*, ** significant at 0.05 at 0.01 level for probability, respectively

About predominance of non-additive genetic effect, Ahmed and Ali, 2008 and Rather et al., (2009). Data in table (6) showed the average degree of dominance and heritability in broad and narrow sense. The average degree of dominance was greater than one for NDT and NDS, Indicating that these traits was under control of over dominance gene effect, While the other traits, the value of the average degree of dominance less than one this indicate that these traits under dominance gene effects. High heritability in narrow sense was reported for all the studied traits. The excepted genetic advance from selection was low for all traits except the KYP and the value was 17.24 while the excepted genetic advance was lower for all studied traits excepted the 300-KW and KYP and the Value was 15.56% and 16.49 respectively.

Table 6: Estimation of genetic parameters of maize in a 5×5 diallel crosses for the studied traits in growing four environments

Parameters	NDT	NDS	PH cm	EH cm	L.A cm^2	K.W (g)	N.R.E	N.K.E	KYP g
Vg	9.60	6.89	98.79	83.15	1946.06	54.19	0.59	8.63	413.32
Vs	18.42	15.00	7045.56	958.95	68370.80	404.18	5.34	135.70	6097.91
Vr	13.02	11.73	95.48	156.26	7650.31	290.39	6.41	43.00	4760.80
Ve	1.34	1.74	267.31	87.38	781.75	13.58	0.33	4.80	116.55
Vg/Vs	0.52	0.45	0.01	0.08	0.02	0.13	0.11	0.06	0.06
VA	19.21	13.78	197.58	166.31	3892.12	108.38	1.18	17.27	862.65

SEA	11.25	8.16	145.04	106.12	2337.44	64.14	0.72	10.53	490.73
VD	18.42	15.00	7045.56	958.95	68370.08	404.18	5.34	135.70	6097.91
SED	7.84	6.55	2941.34	412.75	28101.98	168.31	2.26	56.56	2517.79
VE	1.34	1.74	267.31	87.38	781.75	13.58	0.33	4.80	116.55
SEE	0.13	0.17	27.14	8.87	79.37	1.37	0.03	0.48	11.83
VG	37.64	28.79	7243.14	1125.26	72262.20	512.56	6.52	152.98	6924.56
VP	38.99	30.53	7510.46	1212.65	73043.96	526.15	6.85	157.78	7041.12
h^2_n	0.49	0.45	0.02	0.13	0.05	0.20	0.17	0.10	0.11
h^2_b	0.96	0.94	0.96	0.92	0.98	0.97	0.95	0.96	0.98
	1.44	1.35	0.23	0.58	0.33	0.73	0.66	0.50	0.52
GA	5.38	4.36	3.98	8.35	25.20	8.25	0.79	2.40	17.24
GA as mean	7.05	5.72	2.14	9.46	4.14	15.56	4.91	6.50	16.49

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